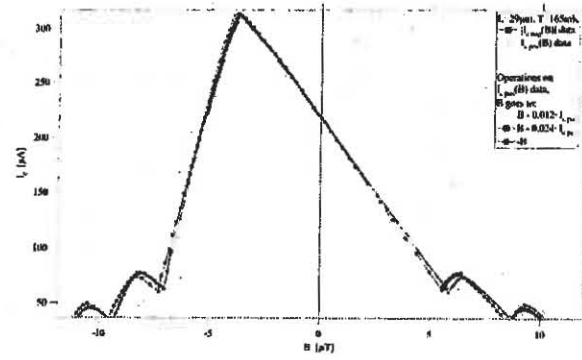
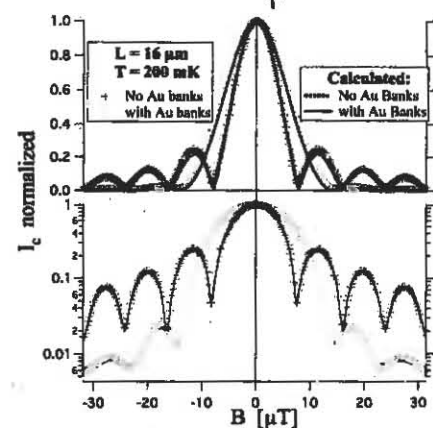
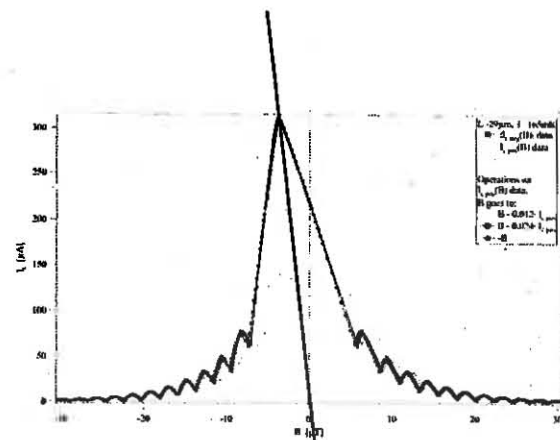
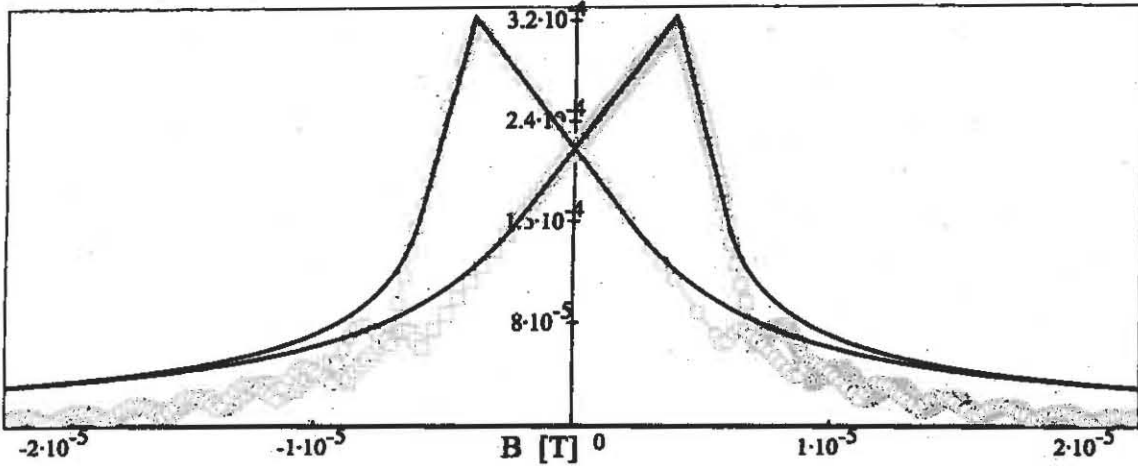
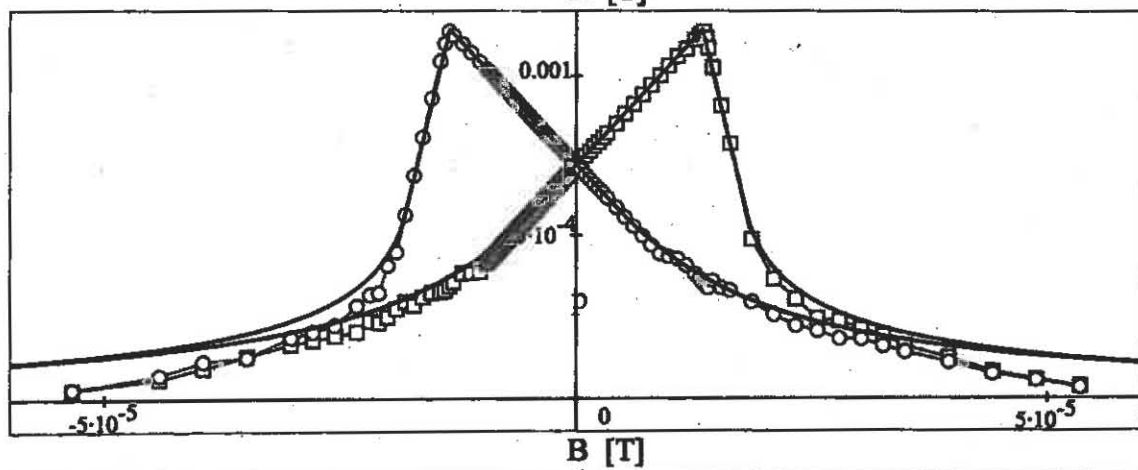
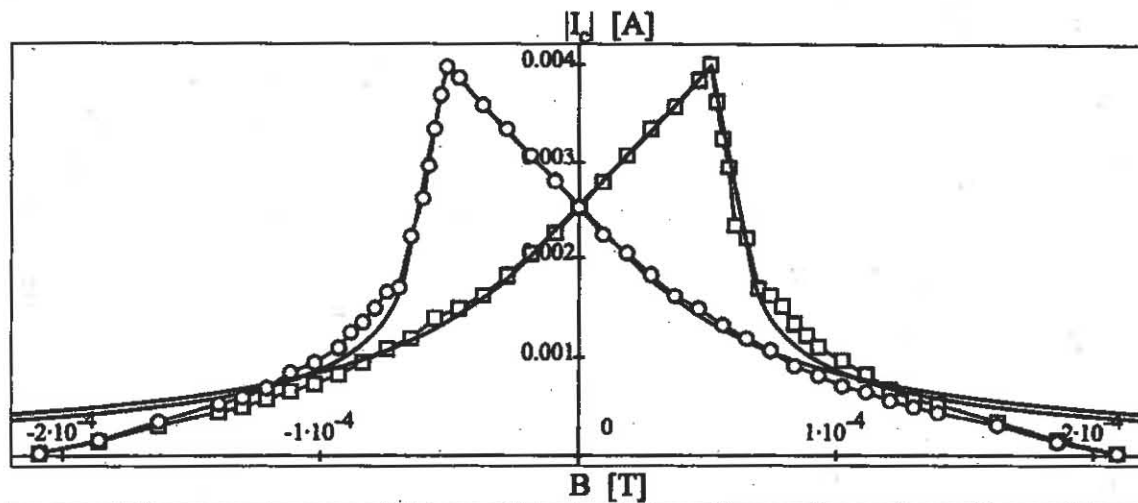
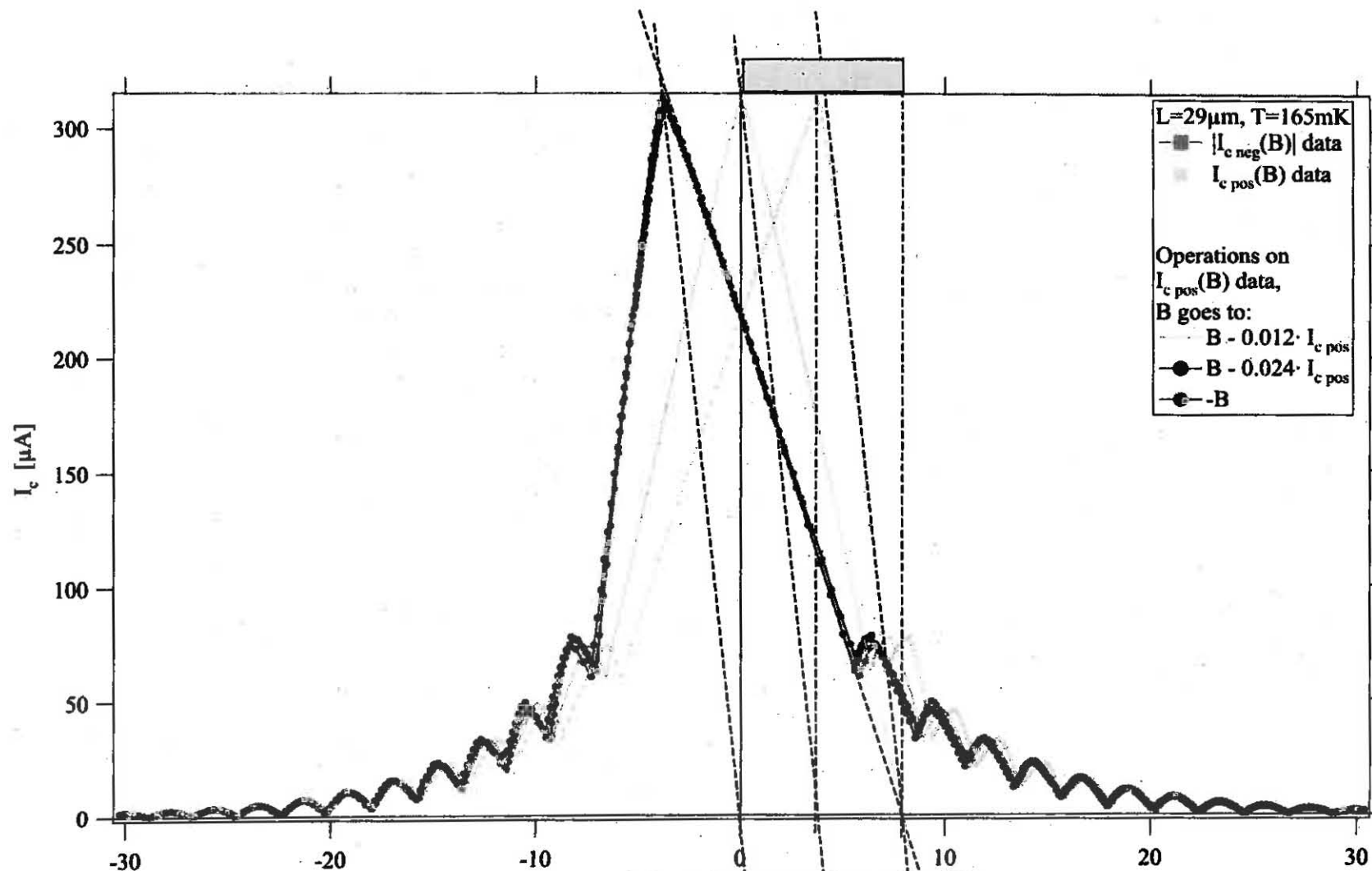


Magnetic field dependance of the critical current in S/N bilayer thin films

Jack Sadleir





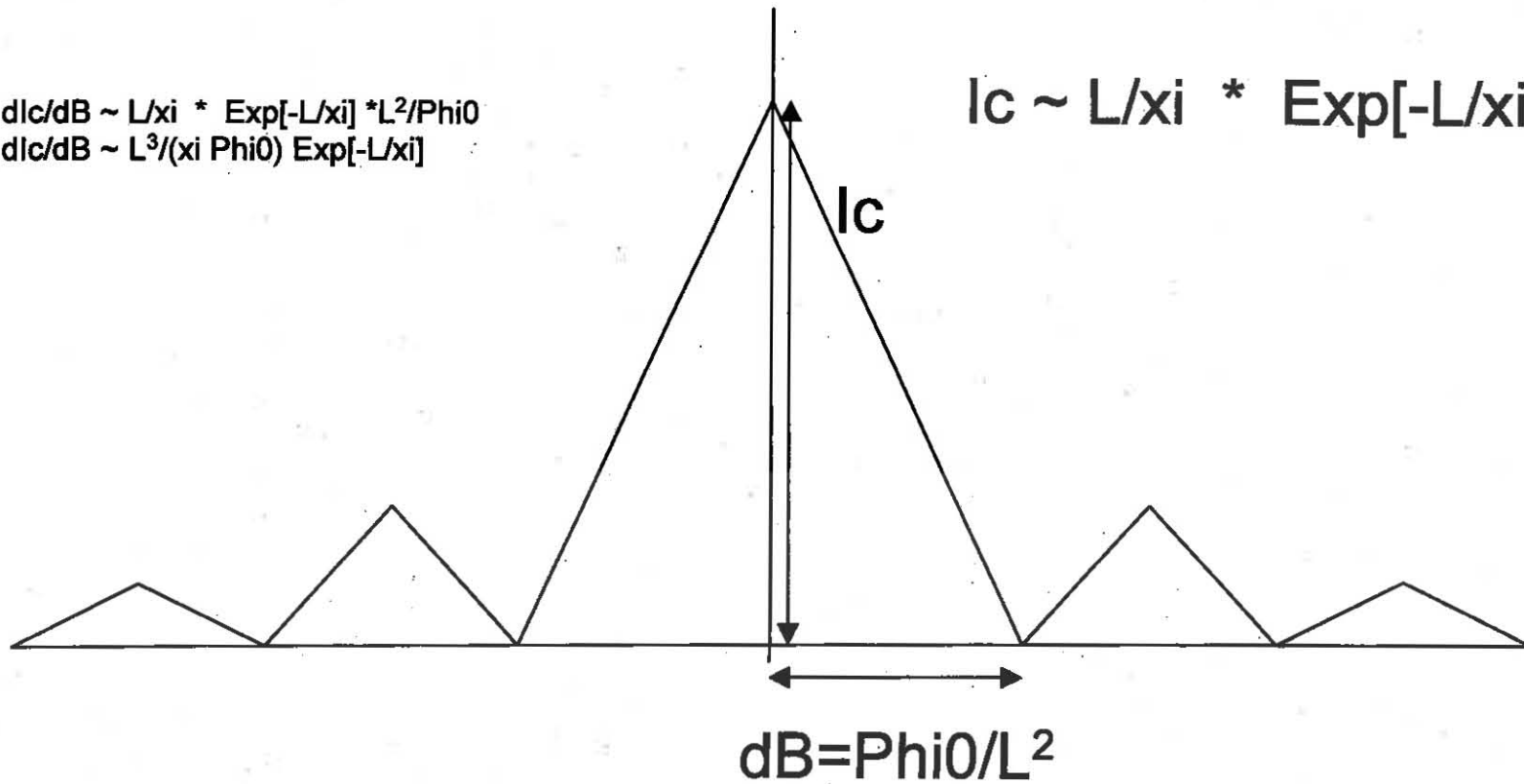
It would follow the minimum value of the intersection of $I_c(B)$ with $B = B_{\text{tot}} = B_a + gI$ line with the line $B = B_a = gI$

smaller thermal G less bias current less self-fielding should be able to take a larger g before becoming double valued.

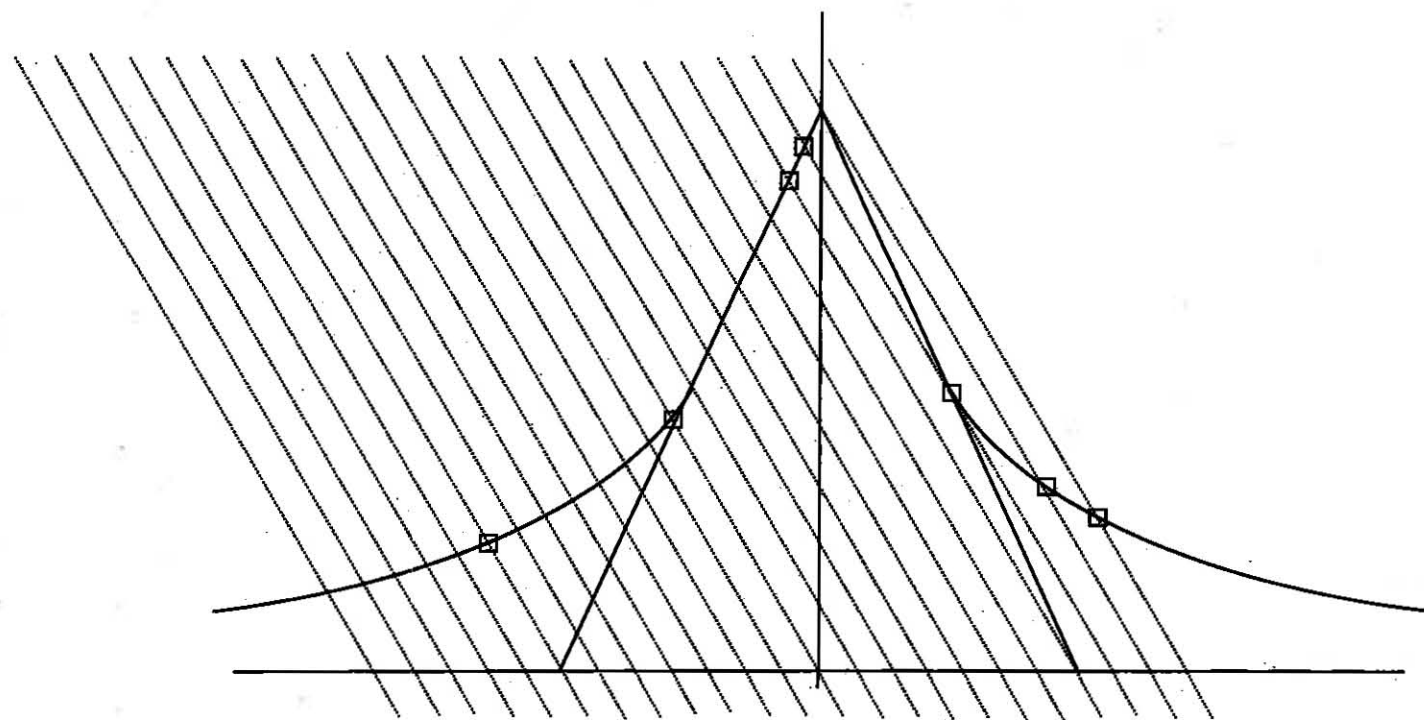
$$\frac{dI_c}{dB} \sim \frac{L}{x_i} * \text{Exp}[-L/x_i] * \frac{L^2}{\Phi_0}$$

$$\frac{dI_c}{dB} \sim \frac{L^3}{(x_i \Phi_0)} \text{Exp}[-L/x_i]$$

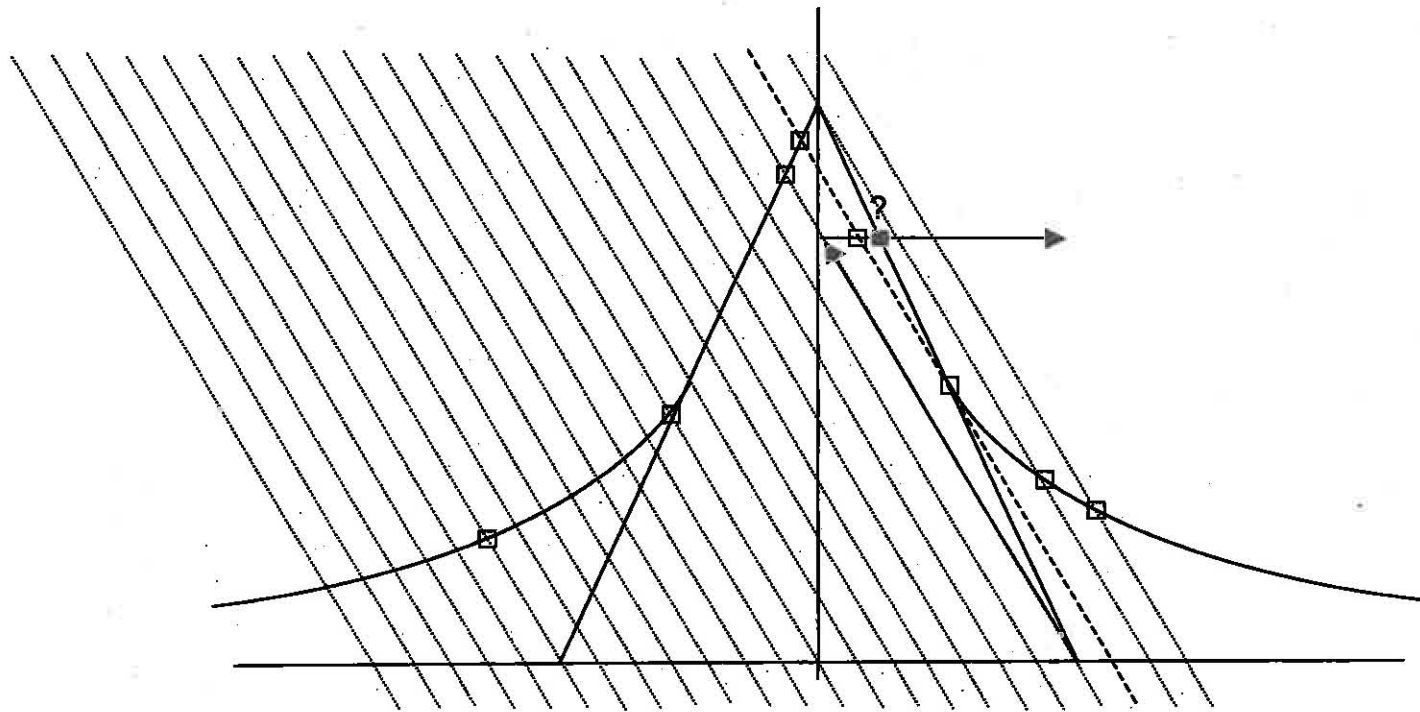
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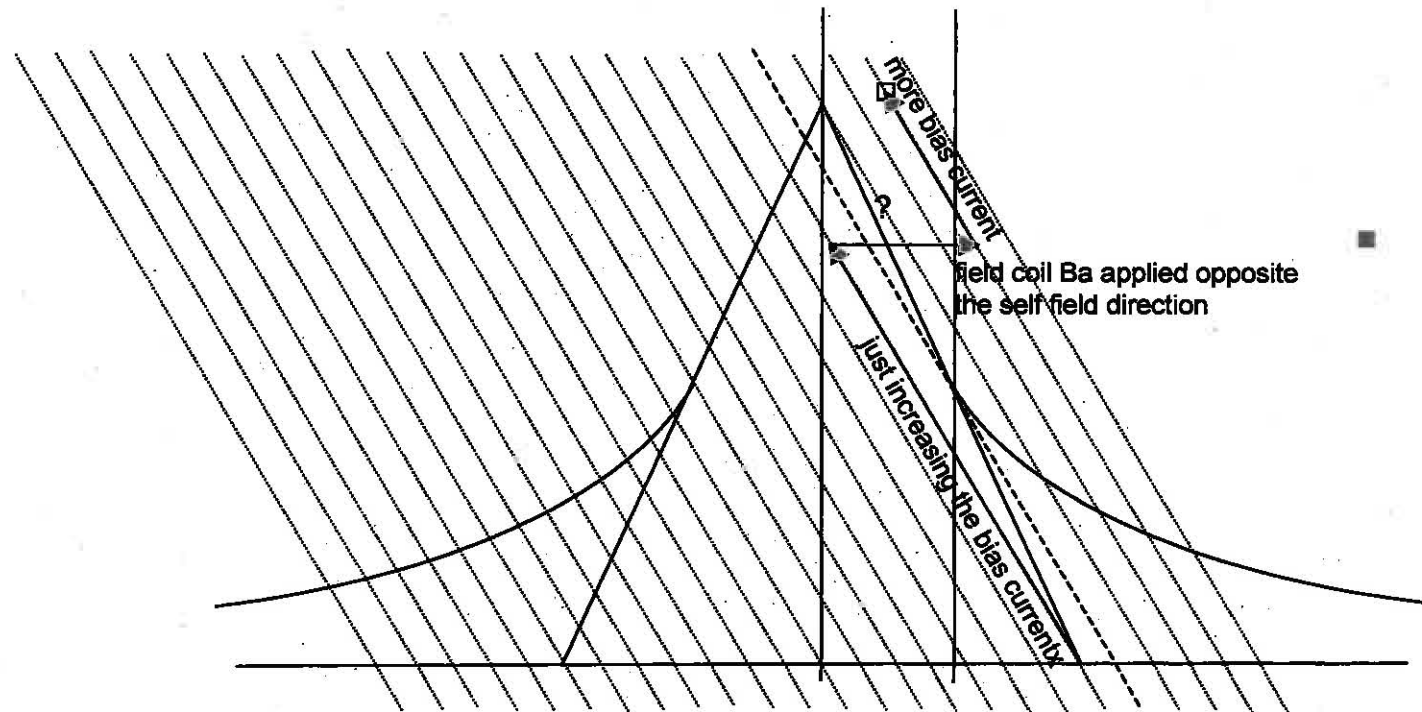


Plot I_{TES} vs B_{tot}



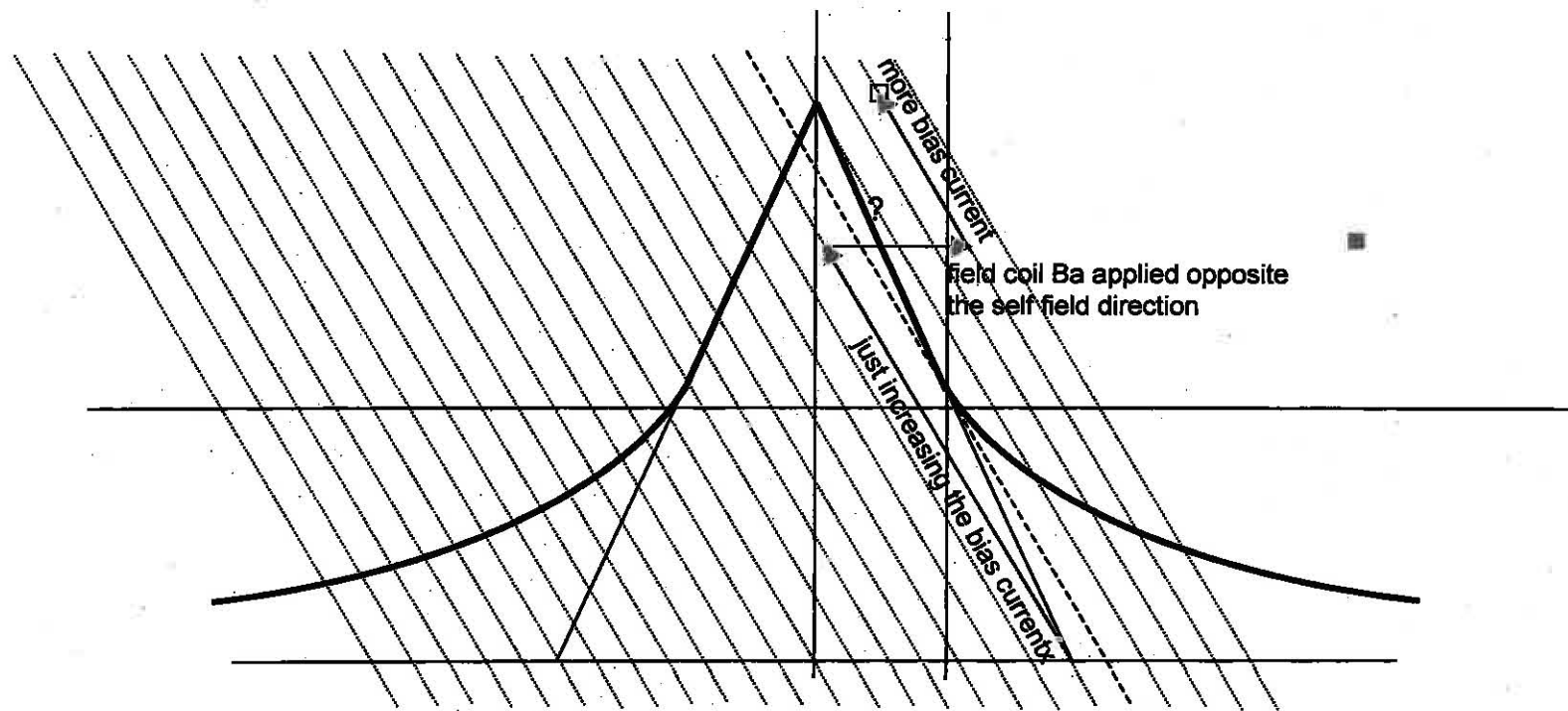
Self-field trajectories. Larger self-field factor g means more sloped lines. Offset of lines comes from different field coil values. You see that your $|g|$ can be so large that the I_c is double valued (for some values of the applied field coil). Therefore it is possible to have "too much" self-field such that the range of positive magnetic feedback operating region is too small or doesn't exist.

Plot I_{TES} vs B_{tot}



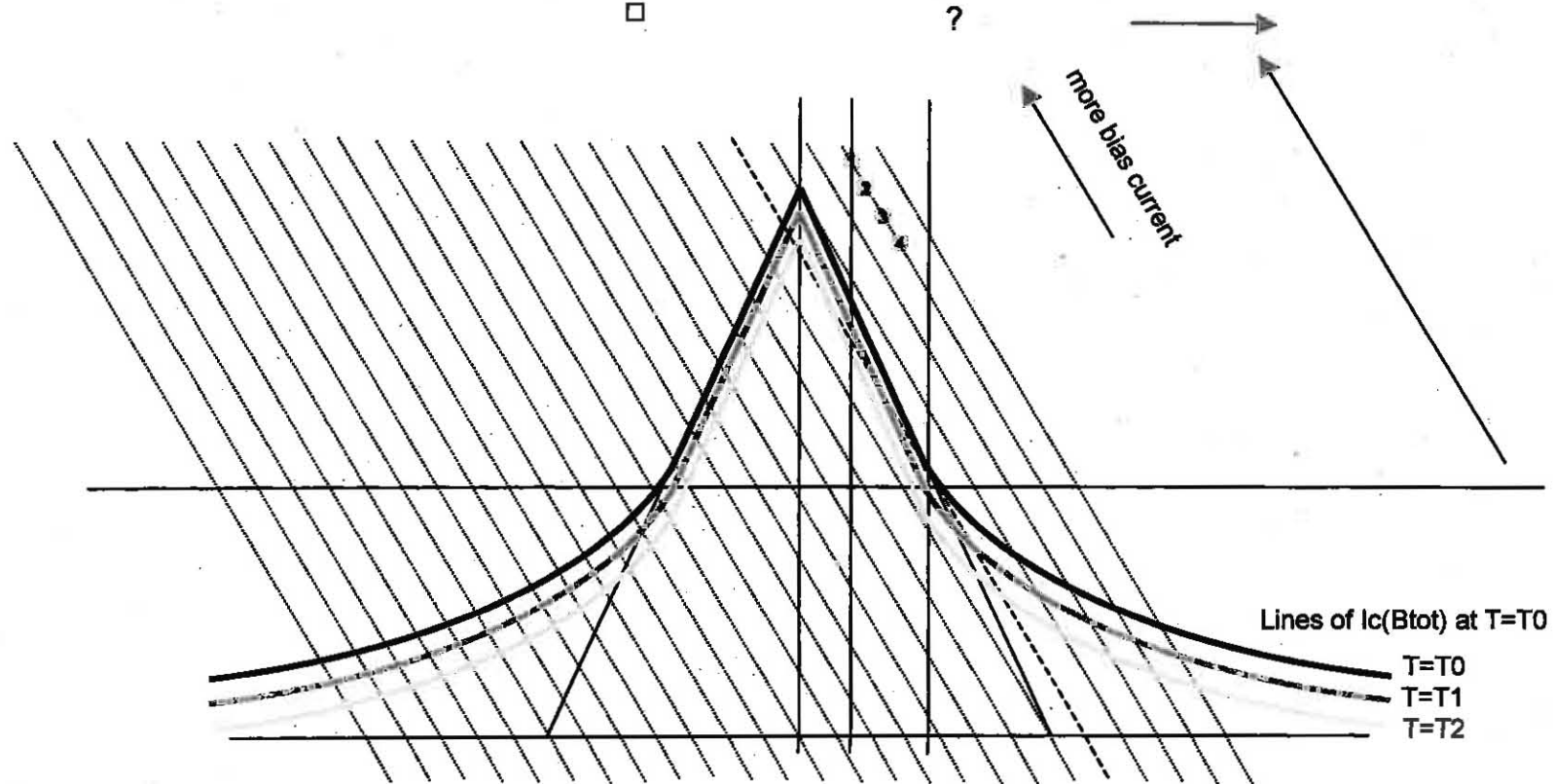
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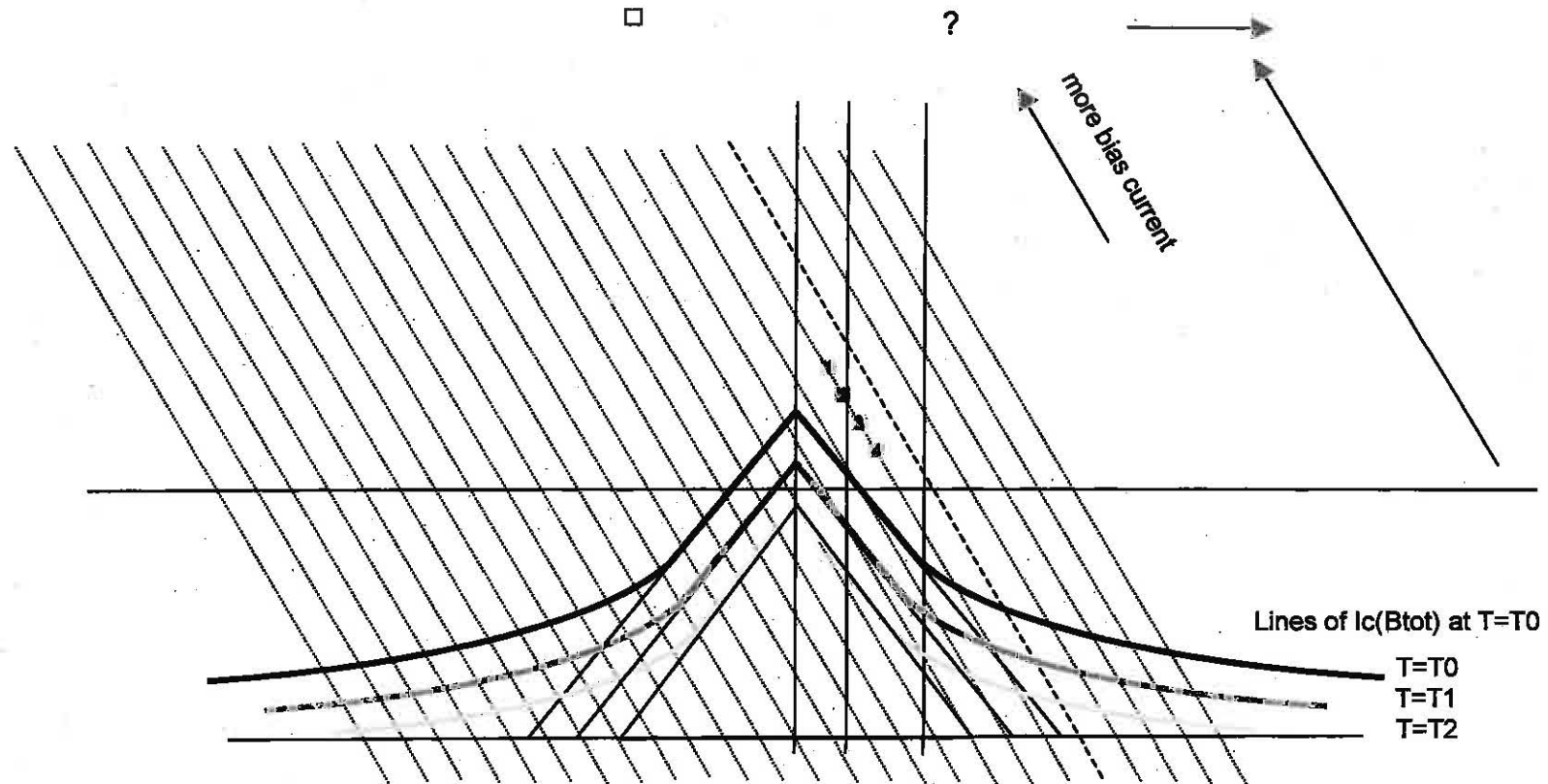
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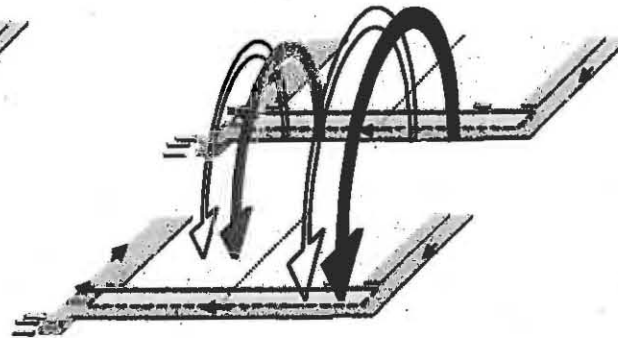
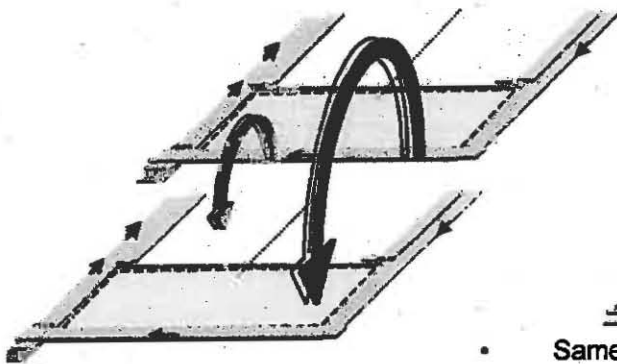


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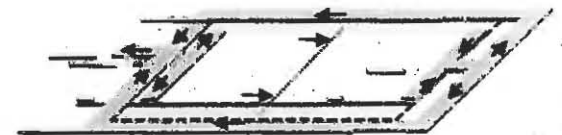
**Designs to Reduce Magnetic
Cross Talk and potentially
improve performance**

Electromagnetic Cross Talk

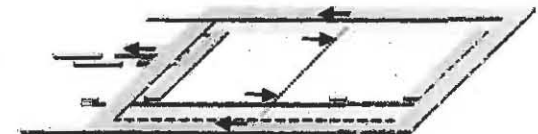
- When the current in pixel #2 changes from absorbing an X-ray there are two types of EM cross talk at pixel #1.
 - Change in local DC field value at TES #1.
 - We want this change in DC magnetic field B value at pixel #1 to be very small relative to the Josephson oscillation period of pixel #1.
 - We can reduce this cross talk by having the current flowing in #2 cancel approximately cancel out better making the field like a higher order pole which will have B decay much faster with distance. E.g. isolated wire lead $B \sim r^{-1}$, versus microstrip $B \sim r^{-2}$
 - Induced EMF in the circuit loop connected to #1.
 - Reduce the geometric area of the leads connecting TES #1.



- Same array pitch
- Reduced loop area (light blue) reduced EMF cross talk
- Larger neighboring dipole lead separation and slightly better current cancellation both leading to reduced DC B cross talk
- Increased lead self field that is large and asymmetric
 - Reduced critical current at zero applied field
 - Increased critical current asymmetry



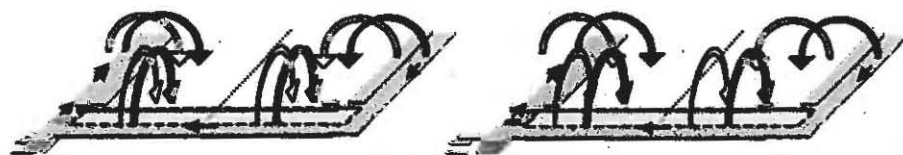
- What loop matters for EMF's?
- Better current cancellation but larger footprint



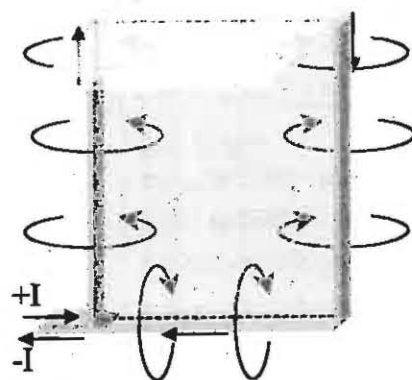
- Opposite ends different but has slightly smaller footprint

Design Considerations

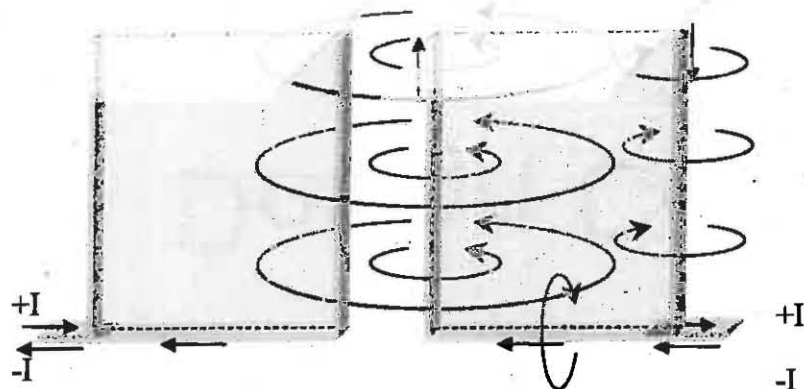
- Small TES footprint: so we can fit many pixels into the densest possible array.
- What is the TES current distribution
 - uniform or concentrated at the edges?
 - Meandering around fingers/stems or not?
 - Depends upon T , R/R_n , and design.
 - This impacts whether the current injection and removal geometry will decrease increase or leave unchanged the critical current of the device and with it determine the I_c asymmetry with bias direction.
- Well canceled TES + Lead current distribution
 - So small DC B crosstalk.
- Small loop
 - (so small EMF crosstalk)
- When the current splits want each arm as uniform as possible
 - E.g. we may not want a microvia on each arm because if nonuniform may split current differently.
- Is a continuous superconducting loop of lead material ok or will it produce undesired effects?



Existing microstrip 2D lead design. Lead self field can be approximated as uniform over a certain range of high T . As loop (blue) becomes smaller self field is larger, I_c asymmetry is larger and I_c at $B_a=0$ is reduced.



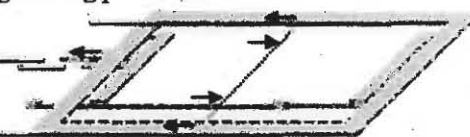
Potential issue with simplest "3D lead" concept.
 (+) still increases space to pull out leaves
 (+) can reduce DC B cross talk.
 (-) concept drawn below shows increased induced EMF cross talk because larger loop area and potential stronger coupling between neighboring pixels.



All have:

1. small loop pick-up area.
2. small B on neighboring pixels

2D, self-field reduces I_c at $B_a=0$ and even B_a maximized I_c



3D. Self-field increases I_c . Fingers.



3D. Self-field increases I_c .



3D, self-field reduces I_c

